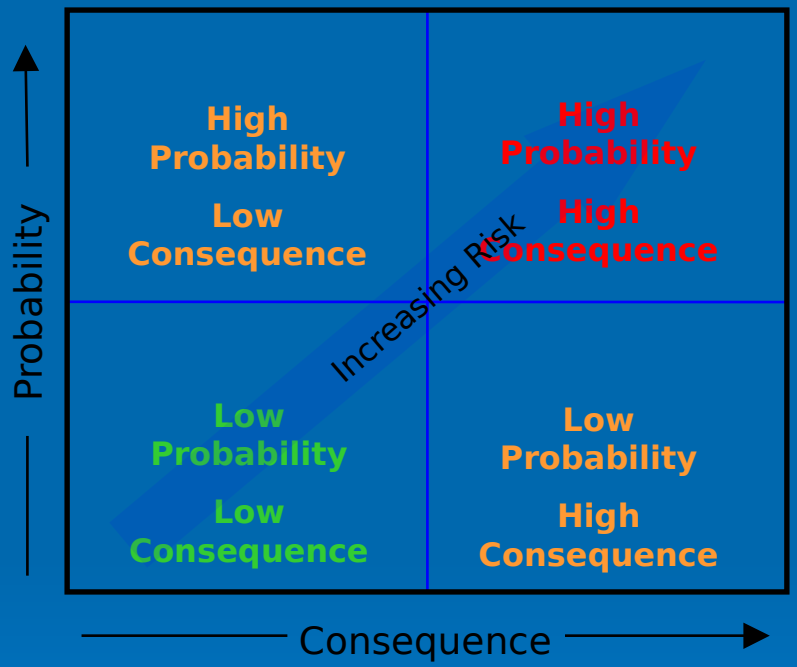
Planning Community of Practice Conference
San Antonio, TX
May 2008

Loss of Life Estimation for Risk Assessment and Planning Studies

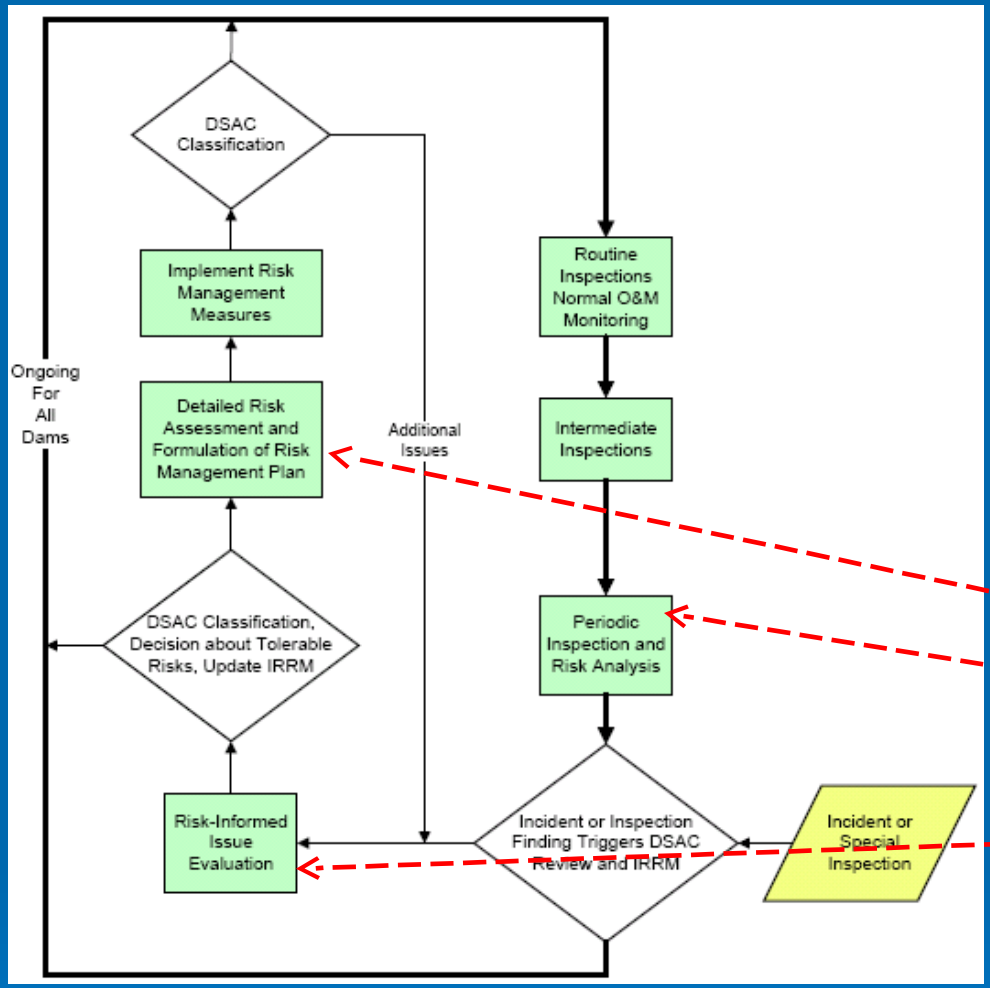
Jason Needham, PE
Hydrologic Engineering Center
Institute for Water Resources (IWR-HEC)

Why estimate life loss?

- To understand existing condition risk (PRA)
  - Risk = probability x consequence
- To compare with tolerable life-safety risk guidelines (e.g. USBR, ANCOLD)
- To identity and justify risk reduction measures (planning process)
  - Structural and non-structural



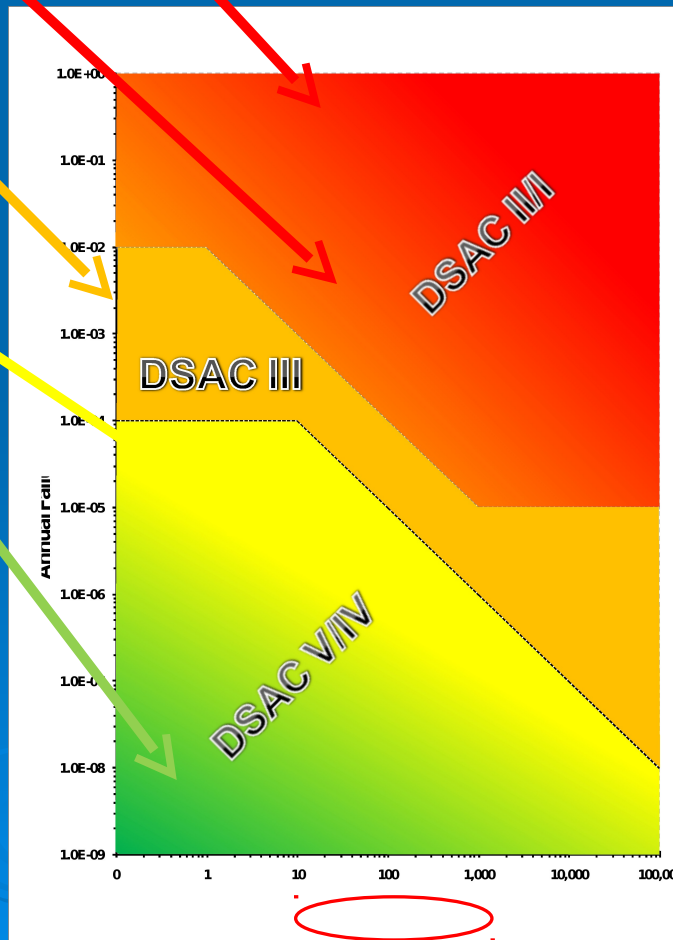
Corps Dam Safety Portfolio Risk Management Process


DSAC Classification
Implement Risk Management Measures
Detailed Risk Assessment and Formulation of Risk Management Plan
DSAC Classification, Decision about Tolerable Risks, Update IRRM
Risk-Informed Issue Evaluation
Ongoing For All Dams
Additional Issues
Routine Inspections Normal O&M Monitoring
Intermediate Inspections
Periodic Inspection and Risk Analysis
Incident or Inspection Finding Triggers DSAC Review and IRRM
Incident or Special Inspection

Outcomes from Risk Assessment	Screening	Periodic Assessment	Issue Evaluation Study	Modification Study
Identify DSAC I & II with low chance of missing any such dams	P			
Preliminary classification of DSAC III - IV	P			
DSAC Confirmation or Reclassification		P	s	s
Initial PRA Input for quantitative risk reporting		P	s	s
PRA Update		P	s	s
Identify all potential failure modes		P	P	P
Identify needed Issue Evaluation Studies (incremental)		P	s	s
Identify O&M, monitoring, EAP, and staff training and other recurrent needs		P	s	s
Prioritization of Issue Evaluation Studies (incremental)		P	s	
Tolerable risk evaluation for existing dam		P	P	s
Identify representative potential risk reduction measures (incremental)			P	s
Prioritization of Dam Safety Modification Studies (incremental)			P	
Confirmation that essential USACE DS guidelines are met for an existing dam (DSAC V confirmation)			P	s
Tolerable risk evaluation for Modification Alternatives				P
Modification decision and justification				P
Prioritization of projects for funding			P	P

USACE Dam Safety Action Classification Table*		
Dam Safety Action Class	**Characteristics of this class**	**Actions for dams in this class**
I **URGENT AND COMPELLING** (Unsafe)	**CRITICALLY NEAR FAILURE** Progression toward failure is confirmed to be taking place under normal operations. Almost certain to fail under normal operations from immediately to within a few years without intervention. **OR EXTREMELY HIGH RISK** Combination of life or economic consequences with probability of failure is extremely high.	Take immediate action to avoid failure. Validate classification through an external peer review. Implement interim risk reduction measures, including operational restrictions, and ensure that emergency action plan is current and functionally tested for initiating event. Conduct heightened monitoring and evaluation. Expedite investigations to support justification for remediation using all resources and funding necessary. Initiate intensive management and situation reports.
II **URGENT** (Unsafe or Potentially Unsafe)	**FAILURE INITIATION FORESEEN** For confirmed (unsafe) and unconfirmed (potentially unsafe) dam safety issues, failure could begin during normal operations or be initiated as the consequence of an event. The likelihood of failure from one of these occurrences, prior to remediation, is too high to assure public safety. **OR VERY HIGH RISK** The combination of life or economic consequences with probability of failure is very high.	Implement interim risk reduction measures, including operational restrictions as justified, and ensure that emergency action plan is current and functionally tested for initiating event. Conduct heightened monitoring and evaluation. Expedite confirmation of classification. Give very high priority for investigations to support justification for remediation.
III **HIGH PRIORITY** (Conditionally Unsafe)	**SIGNIFICANTLY INADEQUATE OR MODERATE TO HIGH RISK** For confirmed and unconfirmed dam safety issues, the combination of life or economic consequences with probability of failure is moderate to high.	Implement interim risk reduction measures, including operational restrictions as justified, and ensure that emergency action plan is current and functionally tested for initiating event. Conduct heightened monitoring and evaluation. Prioritize for investigations to support justification for remediation considering consequences and other factors.
IV **PRIORITY** (Marginally Safe)	**INADEQUATE WITH LOW RISK** For confirmed and unconfirmed dam safety issues, the combination of life or economic consequences with probability of failure is low and may not meet all essential USACE guidelines.	Conduct elevated monitoring and evaluation. Give normal priority to investigations to validate classification, but no plan for risk reduction measures at this time.
V (Safe)	**ADEQUATELY SAFE** Dam is considered safe, meeting all essential USACE guidelines with no unconfirmed dam safety issues. **AND RESIDUAL RISK IS CONSIDERED TOLERABLE**	Continue routine dam safety activities, normal operation, and maintenance.

* At any time for specific events a dam, from any action class, can become an emergency requiring activation of the emergency plan



USACE Dam Safety Action Classification Table

Life loss estimation in planning

- Loss of Life in ER 1105-2-100
  - Section 904 of WRDA 86 requires the Corps to address “The prevention of loss of life” in the formulation and evaluation of alternative plans (p. 2-5).
  - An essential element of the analysis of non-NED recommended plans is the identification of residual risk for the sponsor and flood plain occupants including potential for loss of life due to exceedence of design capacity (p. 3-14).
  - The Corps can provide assistance and guidance to ensure that flood warning preparedness plan will provide necessary response to minimizing the possibility of loss of life (p. E-85).
- Loss of Life in ER 1105-2-101
  - Consideration of increments in project scale beyond the NED plan is permissible to improve project performance and to manage residual risks to people and property. (p. 4)

Tools for estimating life loss

- Current methods used by Corps
  - Dams and levees
    - LifeSim - full version
      - Moderate resource requirement
    - LifeSim - simplified version
      - Modest resource requirement
  - Dams
    - Graham Method
      - Modest resource requirement, current screening tool for dams
  - Levees
    - Jonkman Method
      - Modest resource requirement, current screening tool for levees

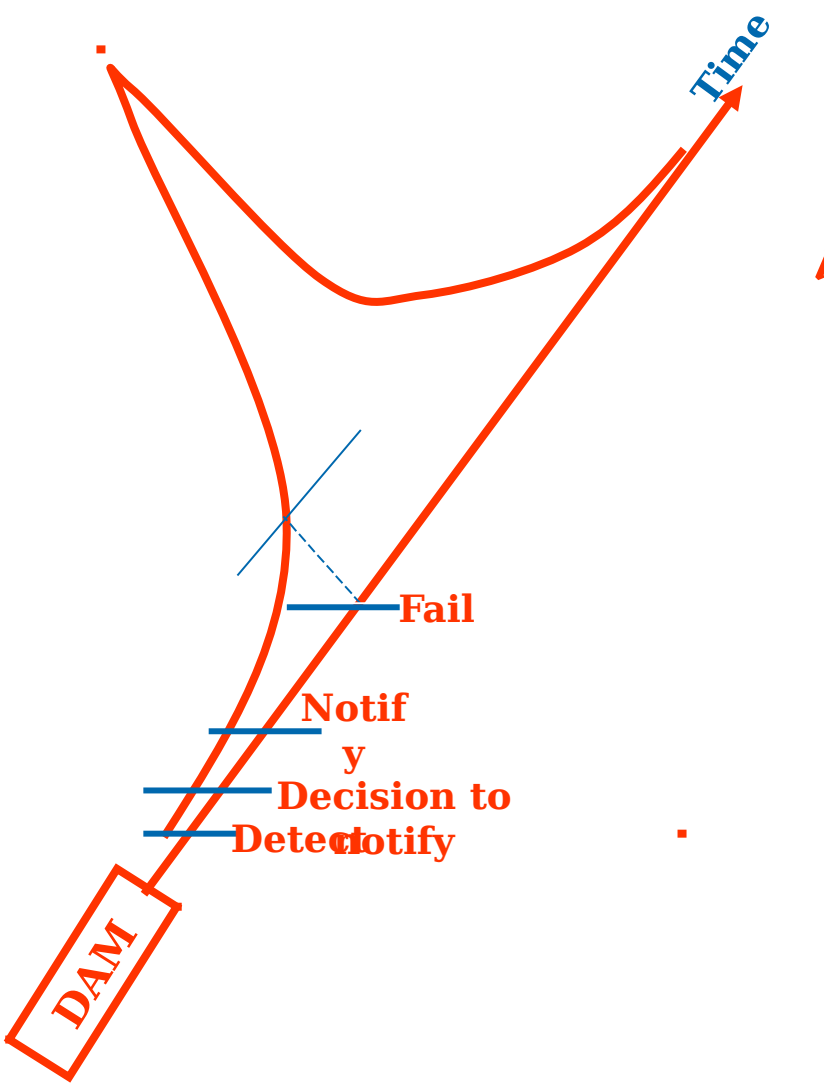
LifeSim Overview

- Institute for Dam Safety Risk Management - USU
  - Funded by USACE, ANCOLD, USU & USBR
- Modular, Spatially-distributed, Dynamic Simulation System
- Two Modes:
  - Deterministic/Uncertainty
- Development Philosophy:
  - Use readily available data:
    - Census, USGS, HAZUS-MH
  - Estimate Loss of Life through simulation
    - Warning and Evacuation Module – redistributes people horizontally and vertically
    - Loss of Shelter Module - categorizes locations of people
    - Life-loss Module – applies fatality-rates

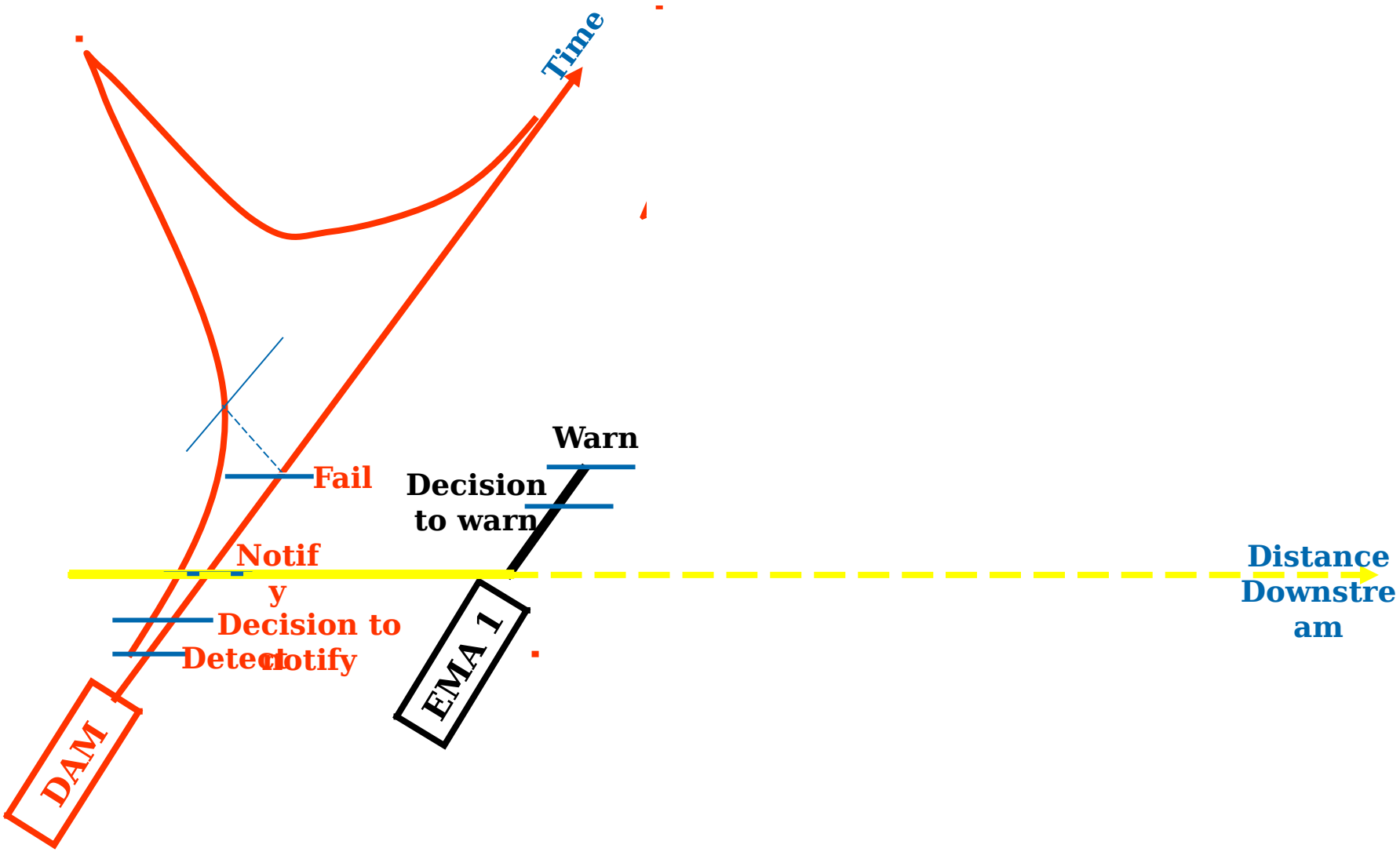
Loss of Life Factors

- Dam failure flood event
  - Breach characteristics
  - Reservoir pool
  - Detection time
  - Extent, velocity, depth, and arrival times downstream
- Number and location of people exposed
  - Spatial distribution, effectiveness of warning, response, and evacuation, shelter
- Loss of life among threatened population
  - Empirical fatality-rates based on flood characteristics

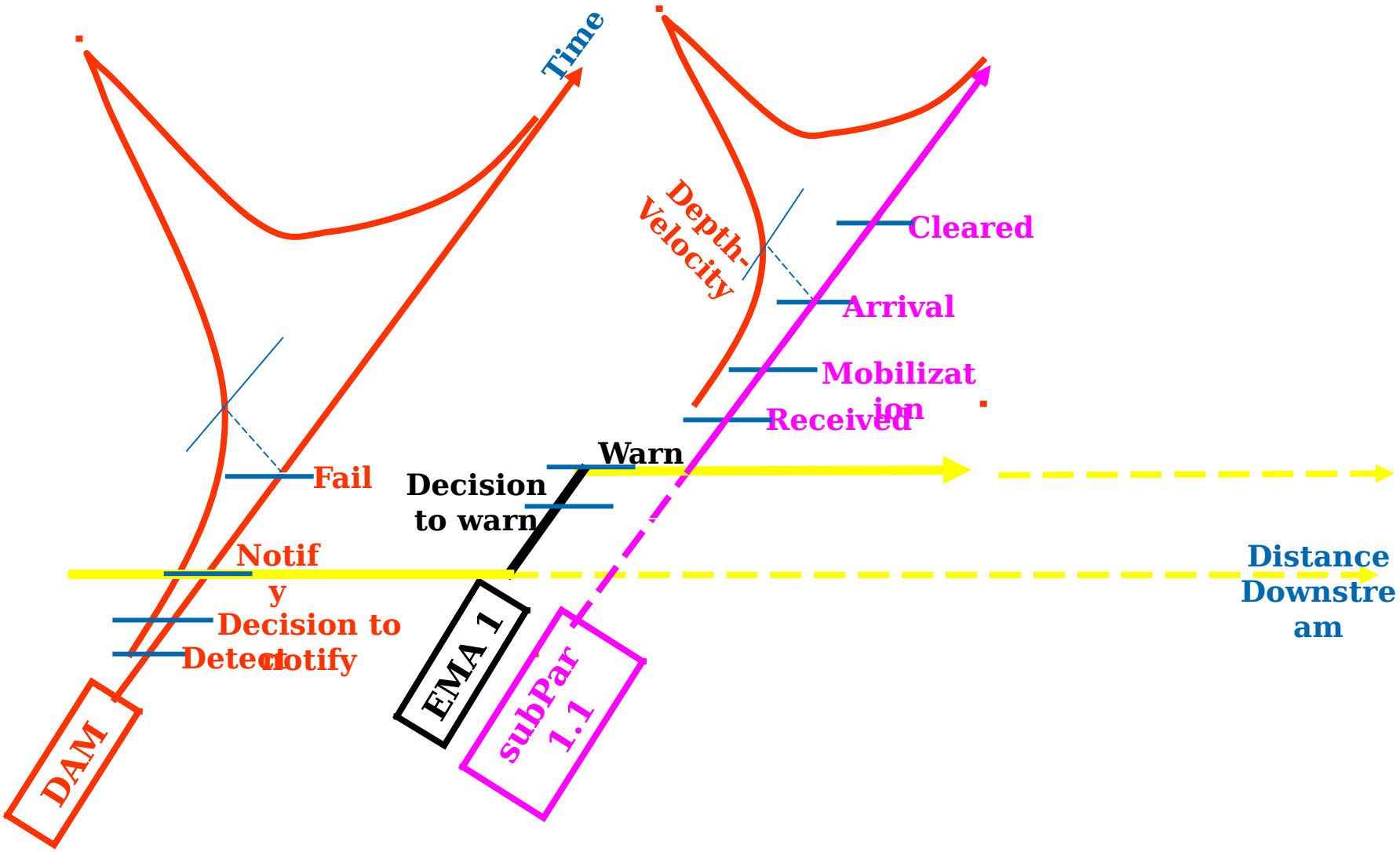
Steps in Warning and Evacuation Procedure



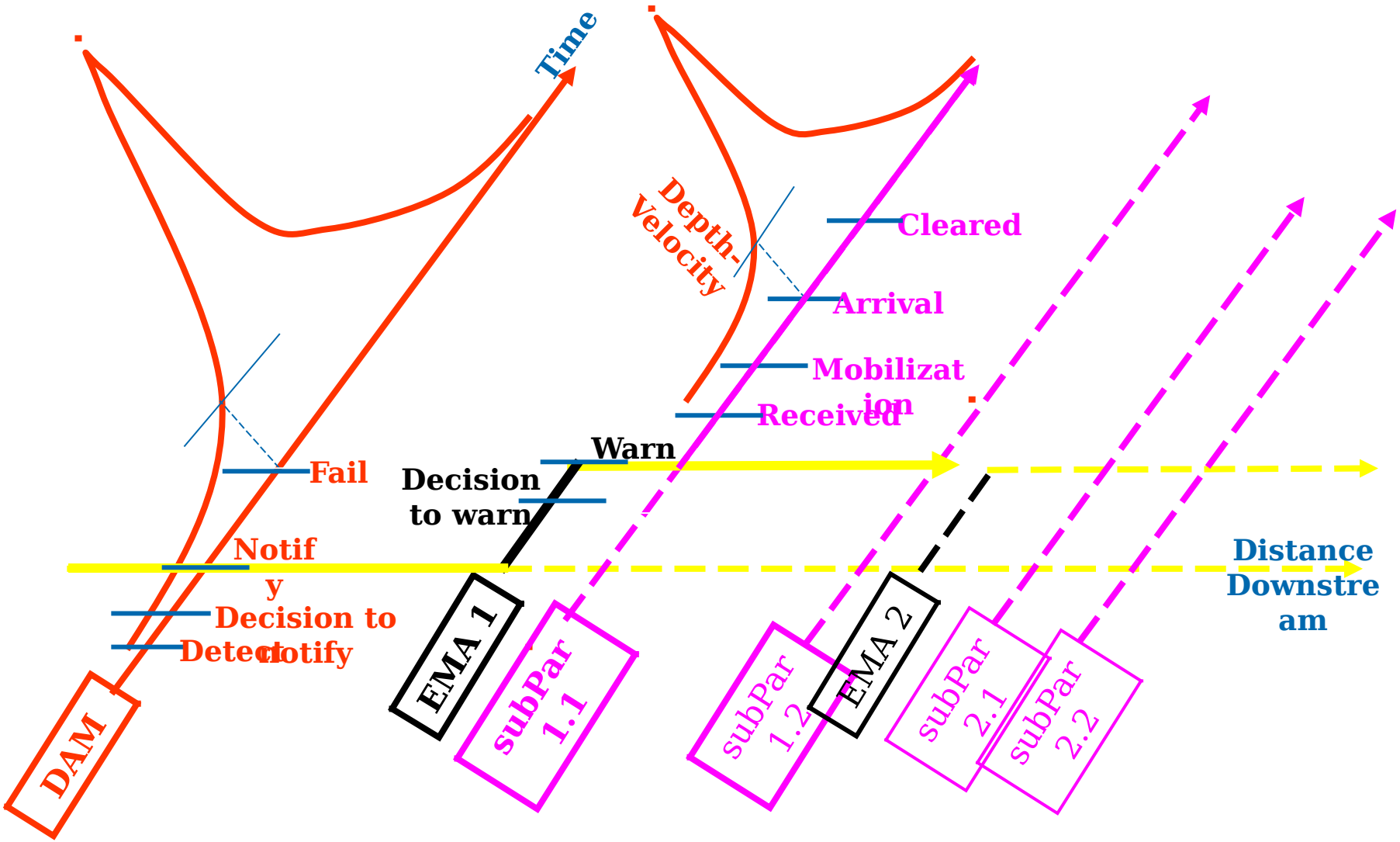
Steps in Warning and Evacuation Procedure



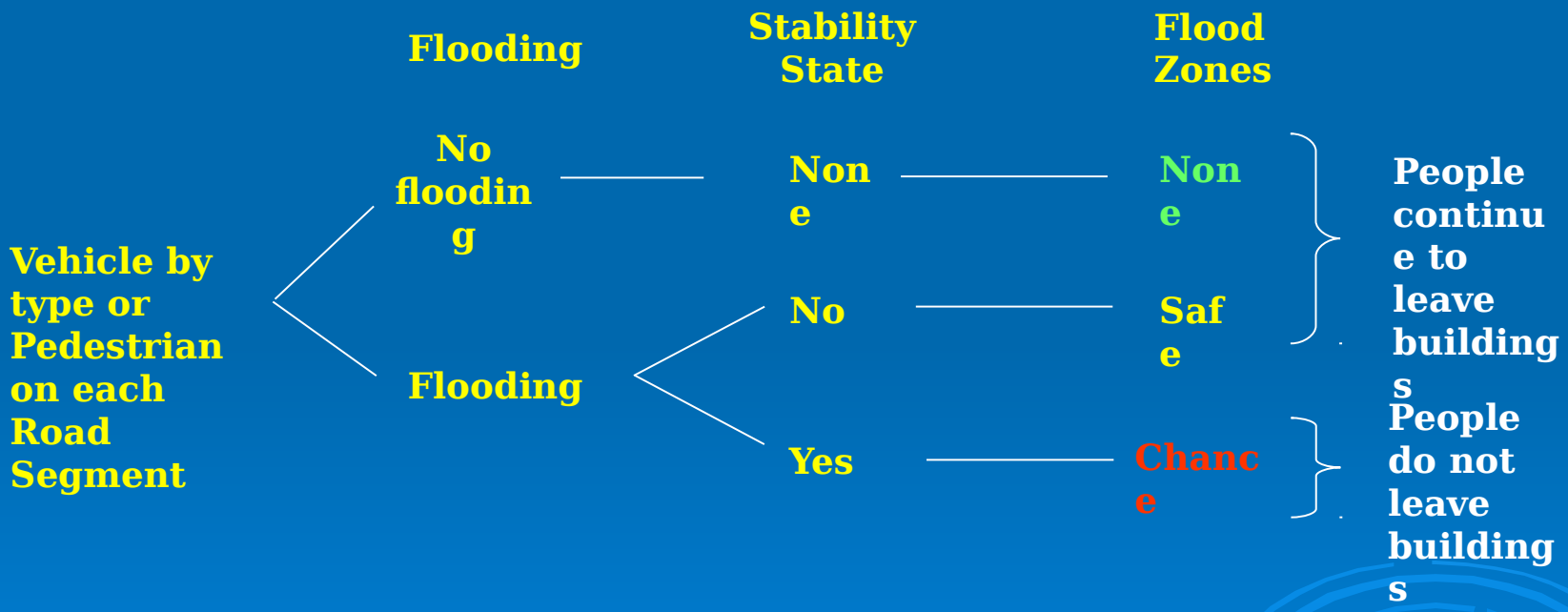
Steps in Warning and Evacuation Procedure



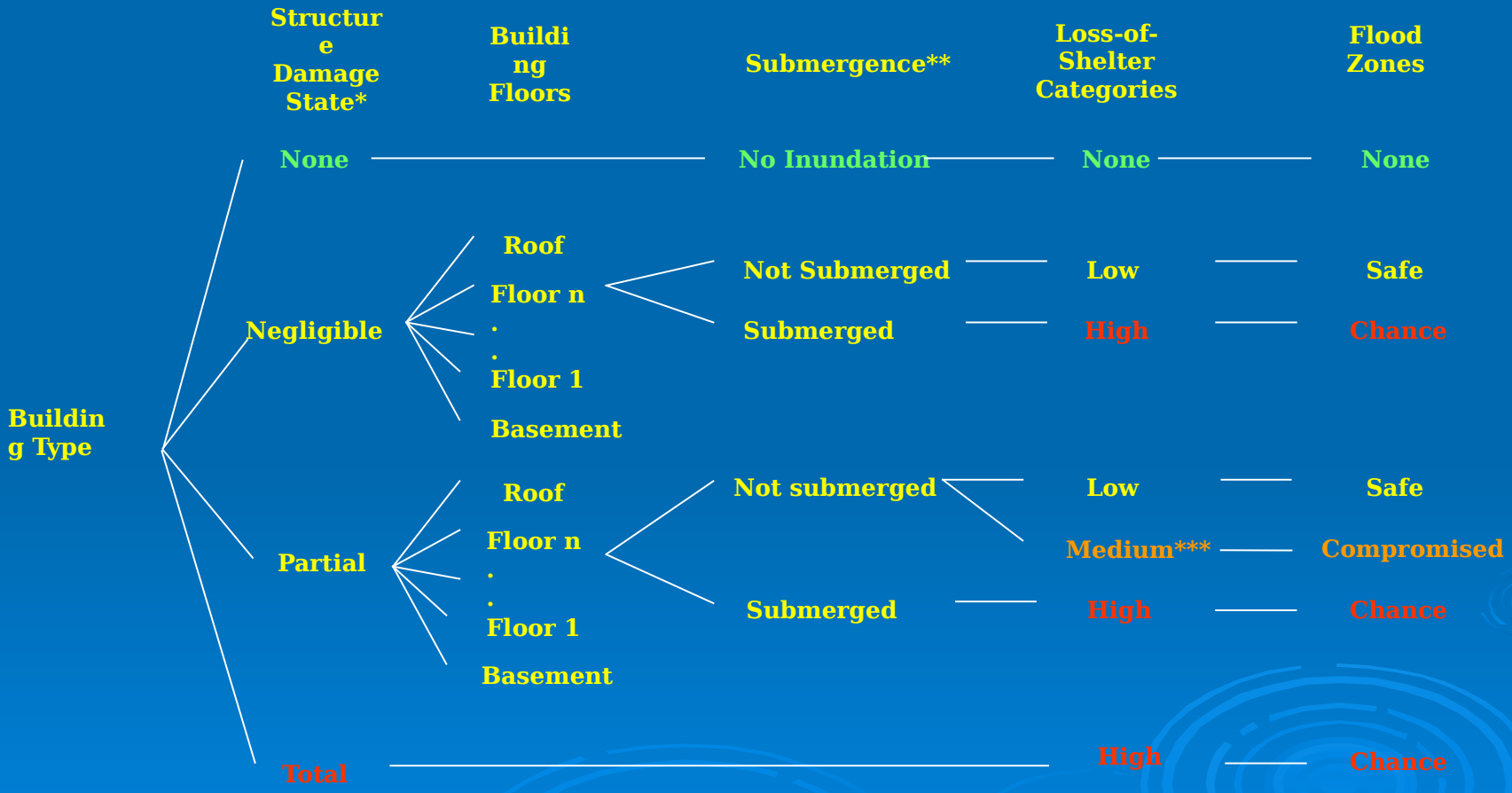
Steps in Warning and Evacuation Procedure



Flood Zones for Vehicles and Pedestrians

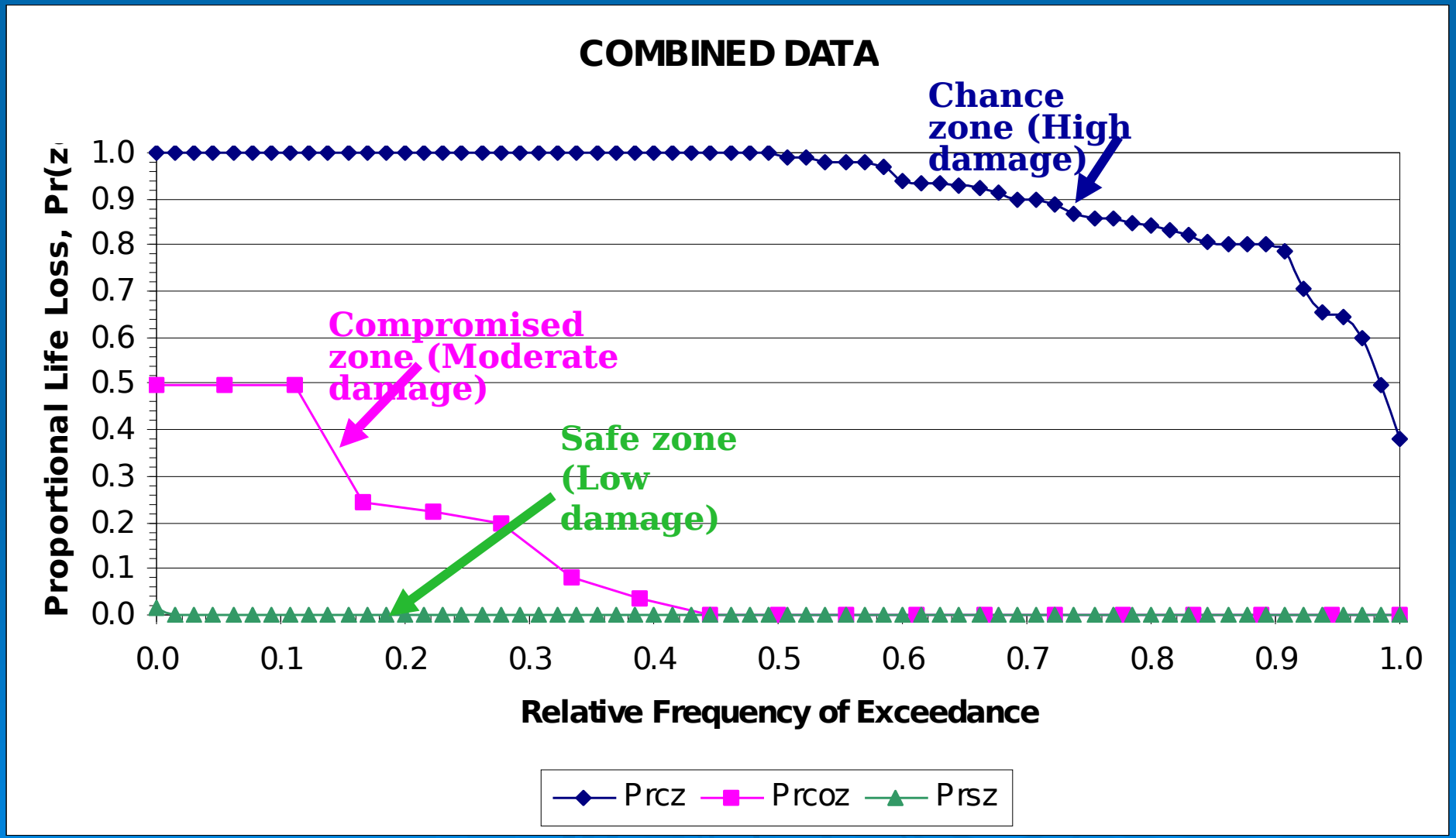


Flood Zones for Buildings

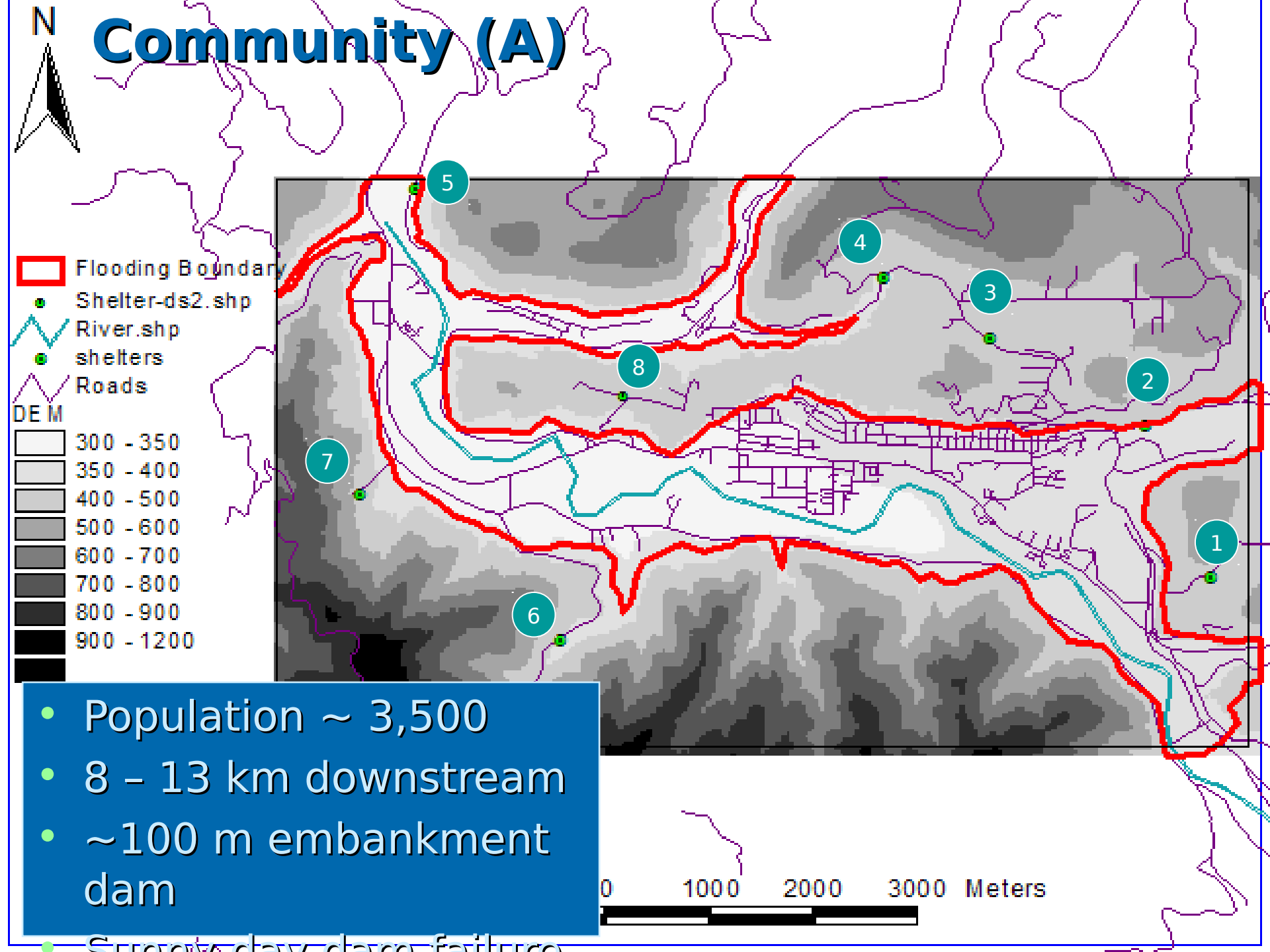


* Use building performance criteria
** Use loss of shelter by submergence criteria
*** Use human stability criteria

Fatality Rate Probability Distributions

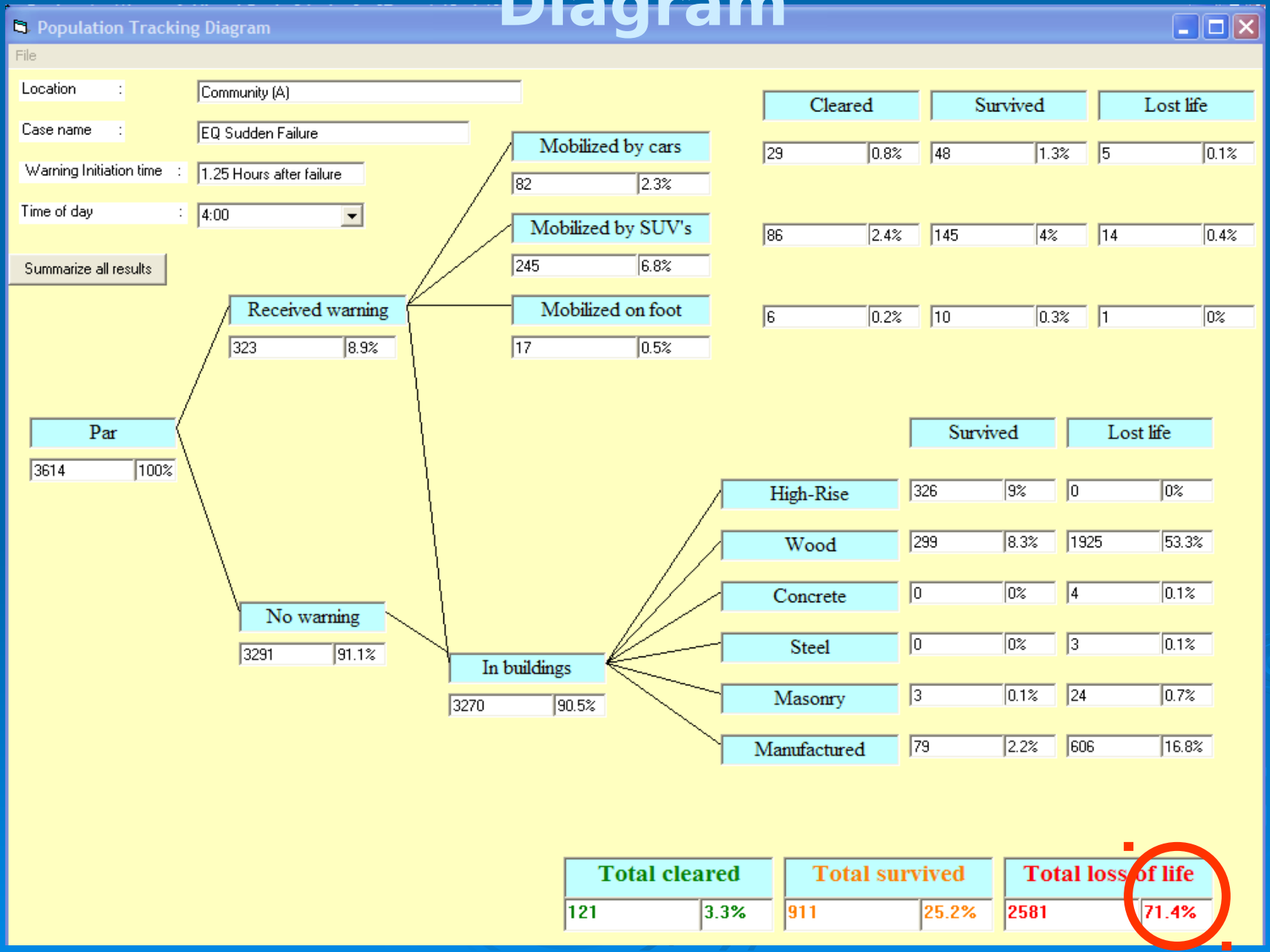


Community (A)

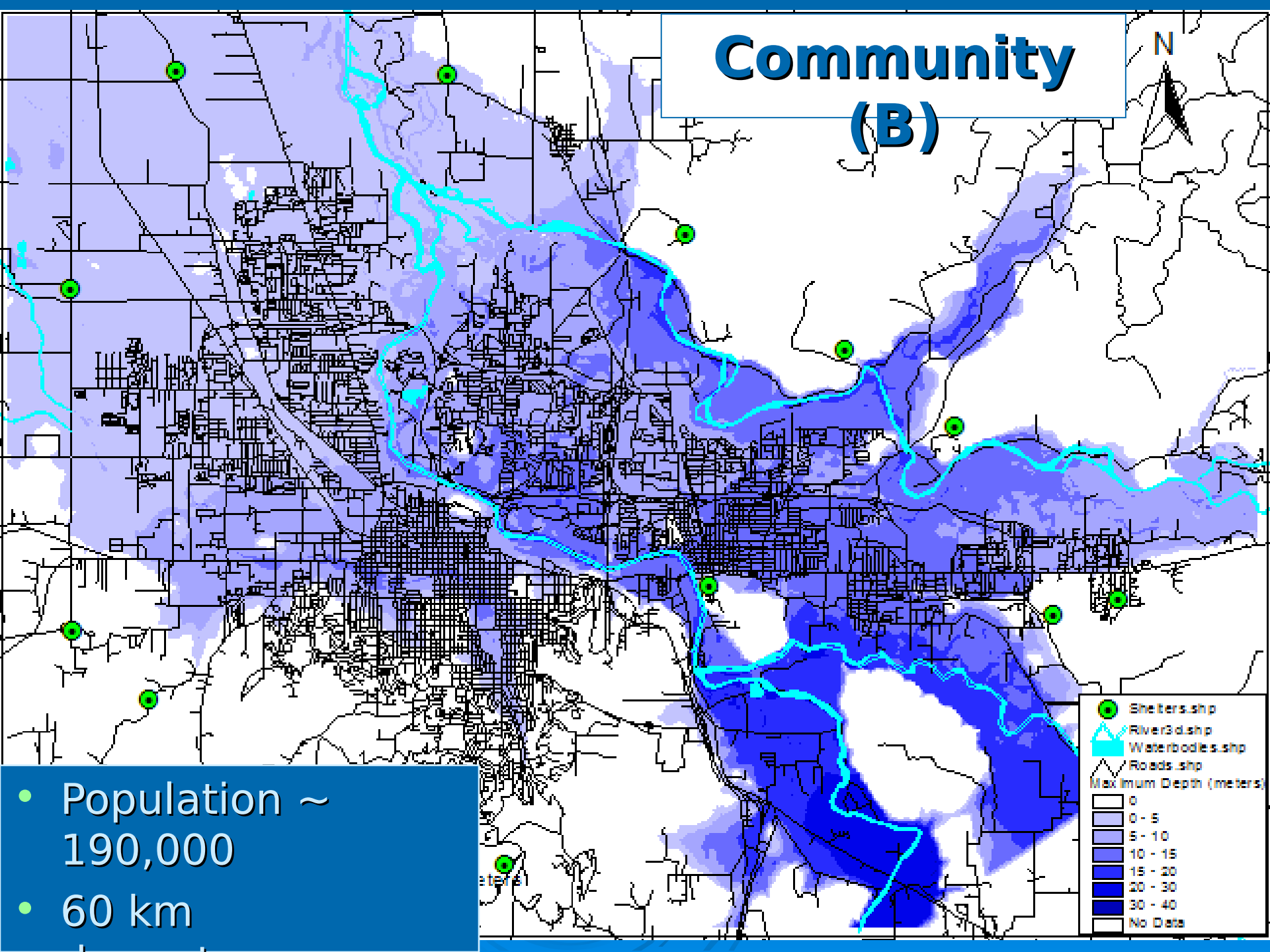


- Population ~ 3,500
- 8 – 13 km downstream
- ~100 m embankment dam
- Sunny day dam failure

Community (A) – Population Tracking Diagram

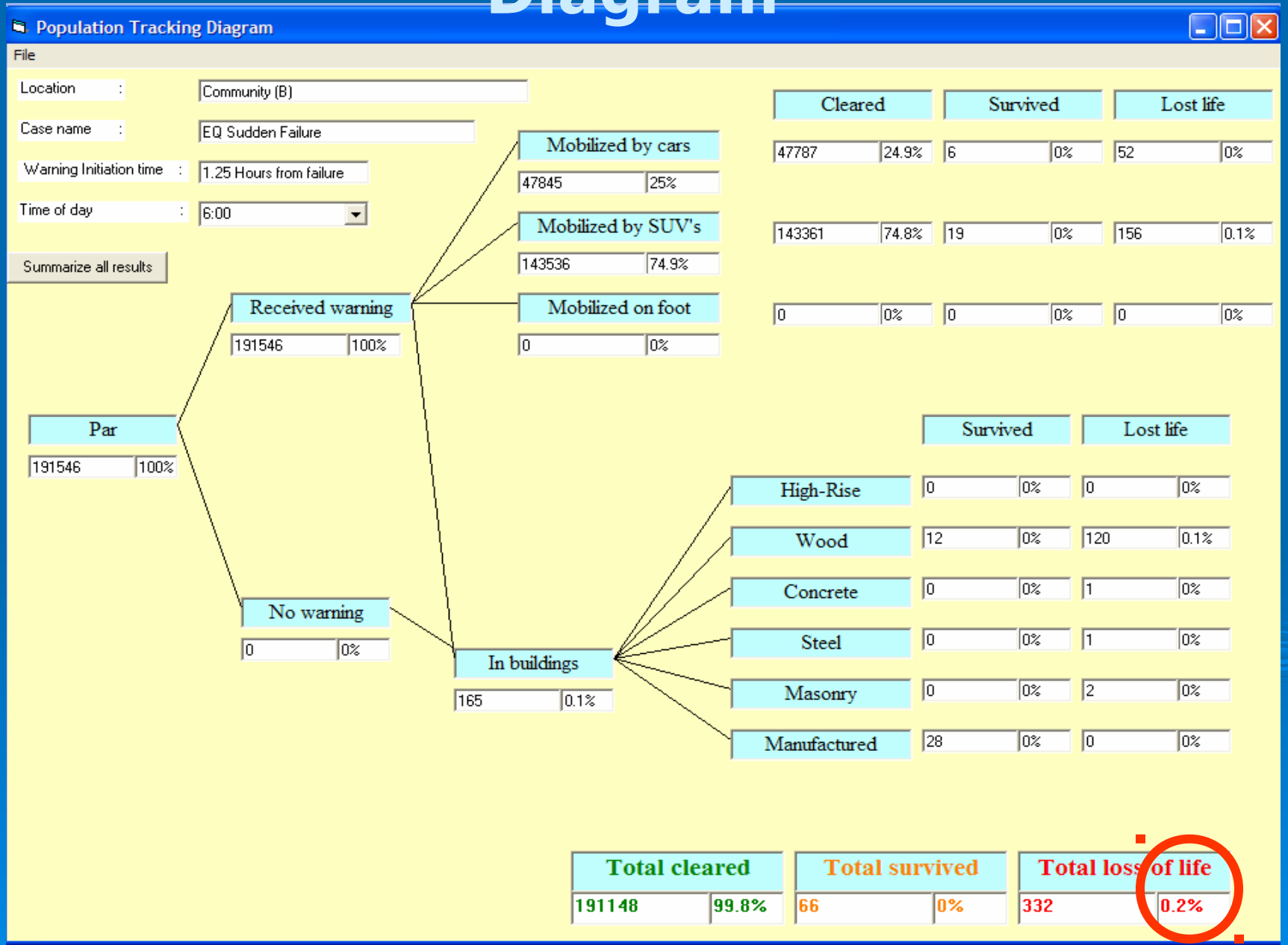


Community (B)



- Population ~ 190,000
- 60 km

Community (B) – Population Tracking Diagram



Conclusions

- Loss of life estimation methods/tools are becoming more available and usable
- Reasonable life-loss estimates are an essential input to Dam & Levee Safety Risk Assessment
- Planning guidance needs to be updated